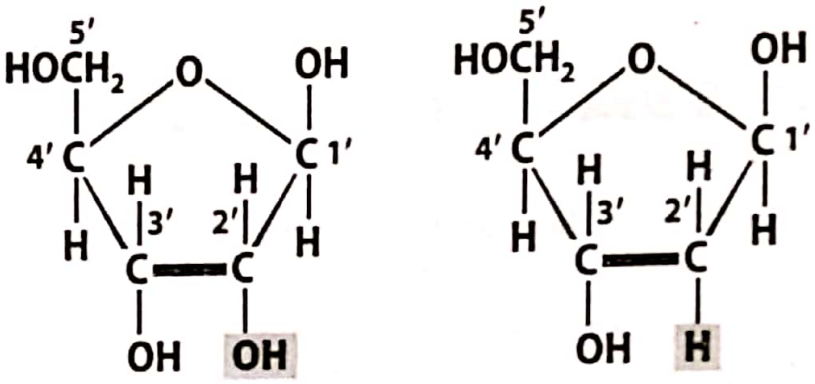
NUCLEIC ACIDS

Nucleic acids are polynucleotide chain (Polymer) composed of units known as nucleotides.

Nucleotide: Nucleotide is composed of three components:

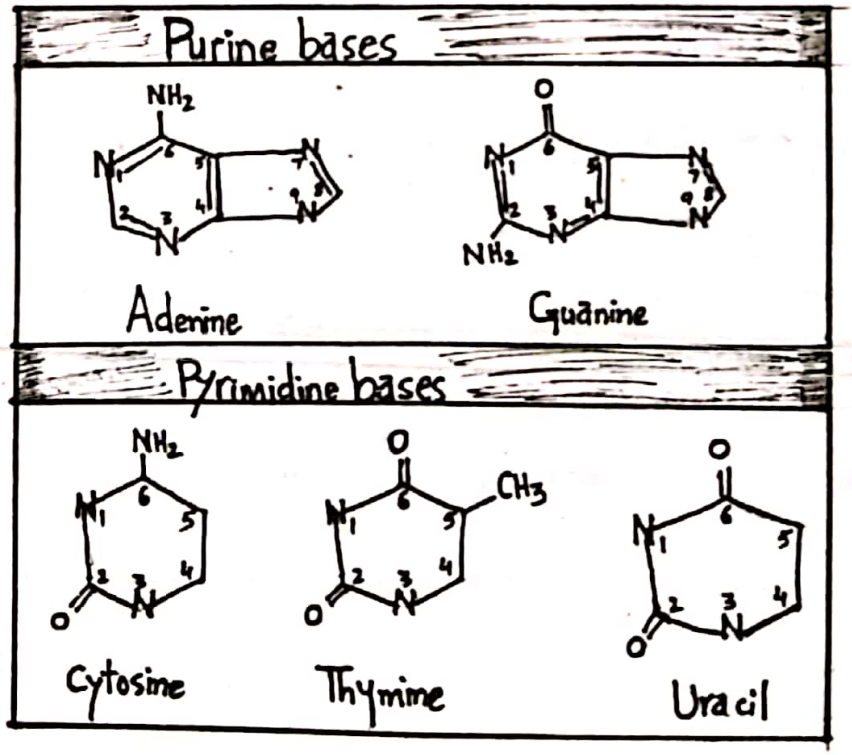
1. Pentose sugar (5-C)
2. Nitrogenous bases i.e. Adenine, Guanine, Cytosine, Thymine, Uracil
3. Phosphoric acid (Phosphate group)

1. **Pentose Sugar S (5-C):** Pentose Sugars are ribose and deoxyribose .RNA nucleotides contain sugars, while DNA nucleotides contain deoxyribose sugars.



Ribose **Deoxyribose**

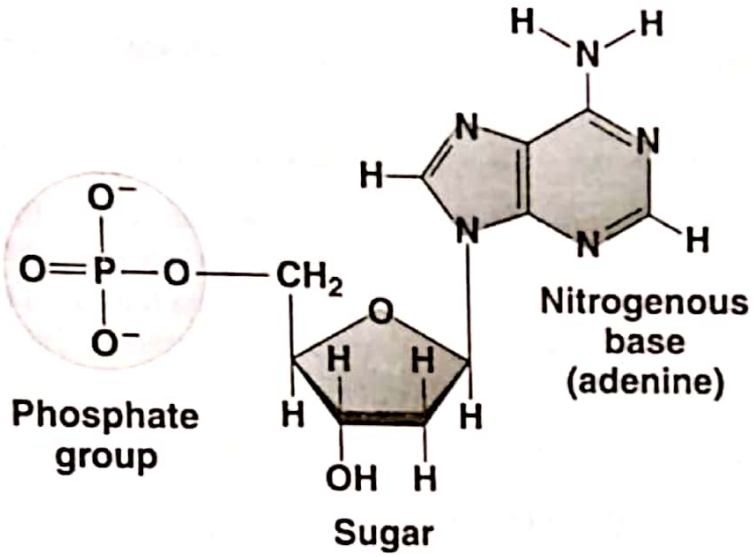
2. **0Nitrogenous bases**: It is classified into two main types.
   - i. **Purine bases:** Purines are double ring compounds e.g. Adenine and Guanine.
   - ii. **Pyrimidine bases:** Pyrimidine are single ring compounds e.g cytosine, thymine and



- **Adenine:** 6-amino purine
- **Guanine:** 2-amino,6-oxy purine
- **Cytosine:** 6-amino, 2-oxy pyrimidine
- **Thymine:** 2,6- dioxy,5-methyl pyrimidine
- **Uracile:** 2,6- dioxy pyrimidine

3. **Phosphoric acid (Phosphate group)..... H_3PO_4**

In a typical nucleotide, the nitrogenous base is attached to carbon No. 1 of pentose sugar while phosphate group is attached to carbon No. 5 of the pentose sugar; the bond formed in between phosphoric acid (H_3Po_4) and hydroxyl (OH) groups of pentose sugar is called ester linkage/bond.



Structure of a nucleotide (Adenine)

In polynucleotide chain, one phosphoric acid is attached to the OH group of carbon No. 3 of pentose sugar while another phosphoric acid is attached to OH group of carbon No. 5 of pentose sugar. It is known as phosphodiester linkage/bond.

TYPES OF NUCLEOTIDES

Nucleotides are classified into three types:

1. Mononucleotides
2. Dinucleotides
3. Polynucleotides

1. Mononucleotides

Mononucleotide occurs singly in the cell e.g.

1. Adenine nucleotide → Adenosine monophosphate (AMP)
2. Guanine nucleotide → Adenosine diphosphate (ADP)
3. Cytosine nucleotide → Adenosine triphosphate (ATP)
4. Thymine nucleotide

Adenosine triphosphate (ATP) → common nucleotide

➢ Structure of ATP

ATP contains three phosphates. When adenine base linked to pentose sugar (Ribose) it forms a struc called adenosine.

Adenosine Monophosphate (AMP):

When adenosine is bonded to a single phosphate, it is known as adenosine monophosphate, attachment of phosphate to adenosine needs energy.

Adenine + Ribose ⟶ Adenosine

Adenosine + phosphate ⟶ Adenosine monophosphate (AMP)

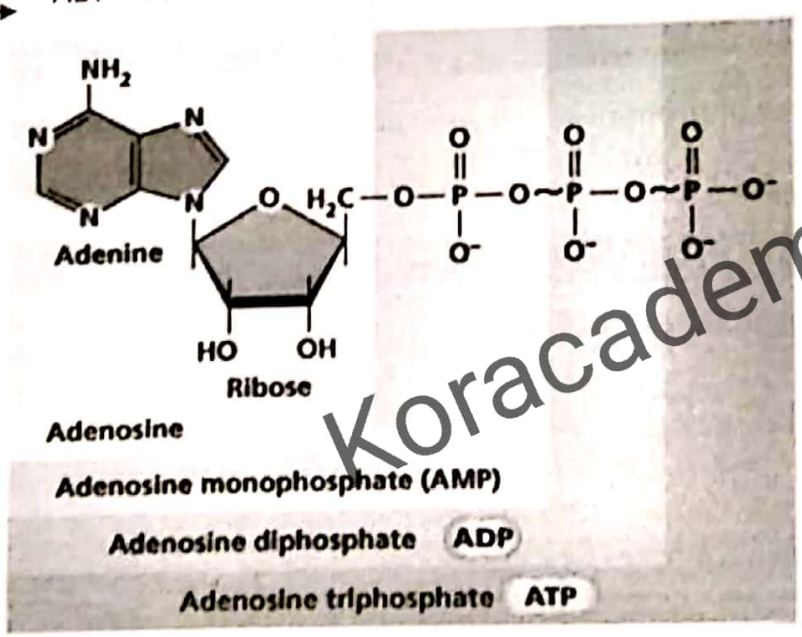
Adenosine Diphosphate: when another phosphate is attached with AMP, it forms adenosine diphosphat (ADP).

AMP + Phosphate ⟶ Adensoine diphosphate (ADP) A-P ~ P

Adenosine Triphosphate: when another phosphate is attached with ADP, it forms Adenosine triphophat (ATP). "A-P~P ~ P" Adenosine triphosphate (ATP) is an energy rich molecule. ATP is the energy currency cell i.e. it provides energy to the cell on its demands. The wavy line bonds (~) between phosphate group indicate high energy bonds. This wavy line bonds (~) are present between the phosphate No. 1 and No. phosphate No. 2 and No. 3. When these wavy line bonds are hydrolysed it release the energy.

The hydrolysis of ATP into ADP and P_i yield almost 7.00Kcal energy.

$ATP + H_2O \xrightarrow{ATPase} ADP + Pi + 7.00\ kcal$



During respiration, when food molecules are broken down into simpler substances, the stored chemic energy is released. This energy is used in the generation of ATP molecules.

2. Dinucleotide

When two nucleotides are bonded together, it forms dinucleotide. If these nucleotides contain Adenine a nitrogenous base, then it is known as adenine dinucleotide.

Coenzymes: (Dinucleotide + vitamin)

When Dinucleotide is attached with vitamin it is known as co-enzyme.

Three important co-enzymes are:

i. NAD^+ (Nicotinamide adenine dinucleotide)

ii. $NADP^+$ (Nicotinamide adenine dinucleotide phosphate)

iii. FAD^+ (Flavin adenine dinucleotide)

Forms of co-enzymes

Co-enzymes exist in two forms:

i. Oxidized form

ii. Reduced form

Oxidized form	Reduced form
NAD^+ ⟶	$NADH_2$
$NADP^+$ ⟶	$NADPH_2$
FAD^+ ⟶	$FADH_2$

In the oxidized state, co-enzyme act as hydrogen acceptor e.g. $NAD^+ + 2H^+ + 2e \longrightarrow NADH_2$

The oxidized forms of co-enzymes are more active than its reduced form.

In electron transport chain of respiration, co-enzymes act as hydrogen carriers.

During this process, they are alternatively reduced and oxidized.

3. Polynucleotides

When many nucleotides are bonded together, they form polynucleotide structure.

For Example DNA and RNA

➢ DNA (Deoxyribonucleic acid)

Discovery of DNA: James Watson, Francis crick and Maurice Wilkins (1916-2004) jointly received the Nobel Prize in physiology or medicine for their explanations of DNA model in 1953.

Main points of DNA model

According to this model:

i. DNA is a double helical/ stranded structure.

ii. The two helices are anti- parallel to each other.

i.e. $5' \longrightarrow 3'$

$3' \longleftarrow 5'$

iii. The backbone of double stranded structure is composed of sugar and phosphate.

Iv. Nitrogenous bases i.e. adenine form double bond (hydrogen bonds) with thymine (A-T) and cytosine form triple (hydrogen bond) with guanine (C-G).

The diameter of DNA molecule is 2nm. The distance between nitrogenous bases is 0.34nm.

➢ Structure of DNA

DNA is a polynucleotide chain structure. Nucleotides are the building blocks of DNA molecule.

Nucleotide is composed of three components

i. Pentose sugar (Deoxyribose)

ii. Nitrogenous bases i.e. adenine, guanine, cytosine and thymine.

iii. Phosphoric acid (Phosphate group).

Four Different types of nucleotides present in DNA molecule are

i. Adenine deoxyribonucleotide

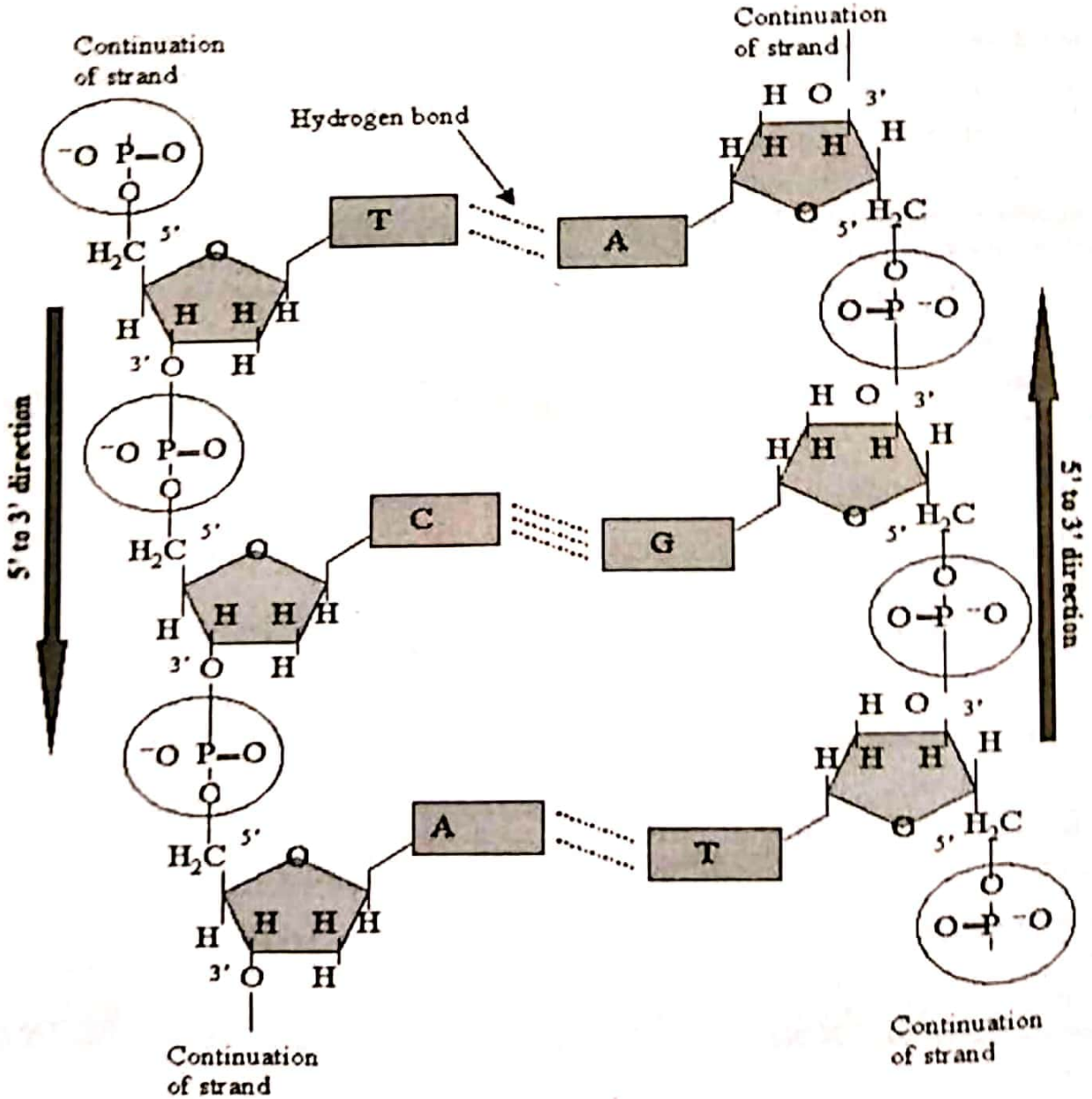
ii. Guanine deoxyribonucleotide

iii. Cytosine deoxyribonucleotide

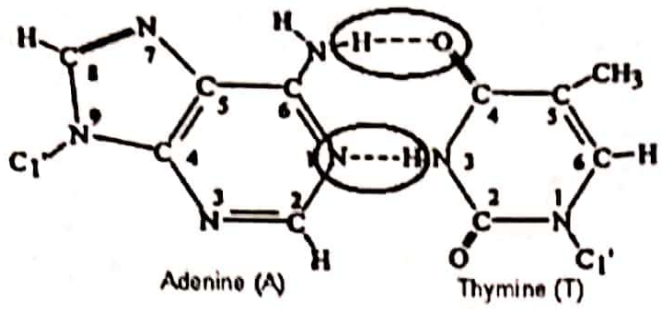
iv. Thymine deoxyribonucleotide.

These four nucleotides in the DNA molecule are bonded to one another in such a manner that the sugar o one nucleotide is bonded to the phosphate group of next nucleotide.

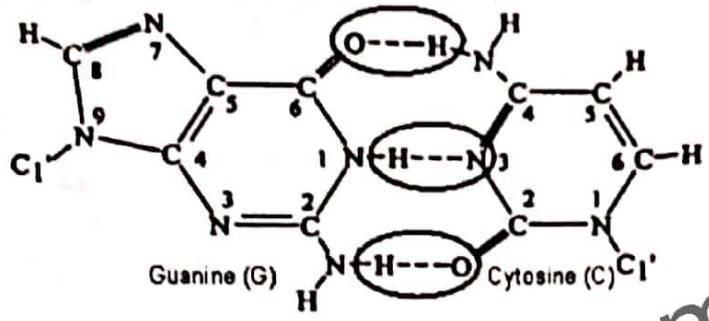
In this way the nucleotides form a linear DNA molecule called a strand in which the backbone is made up o sugar alternating with the phosphate group. The bases are projected to one side of the strand. Th sequences of nucleotides in the DNA of different individuals are different.



Adenine-Thymine base pair



Guanine-cytosine base pair



STRUCTURE OF RNA

Ribonucleic acid (RNA)

RNA is a single stranded structure.

Composition of RNA

RNA is polynucleotide chain structure.

Polynucleotide structure of RNA is composed of four different types of nucleotides: these nucleotides contain ribose sugar.

1. Adenine ribonucleotide
2. Guanine ribonucleotide
3. Cytosine ribonucleotide
4. Uracil ribonucleotide

In RNA, the base Uracil occurs instead of thymine base nucleotides are linked in the same manner is in the DNA molecule.

Types of RNA

There are **three** types of RNA molecules:

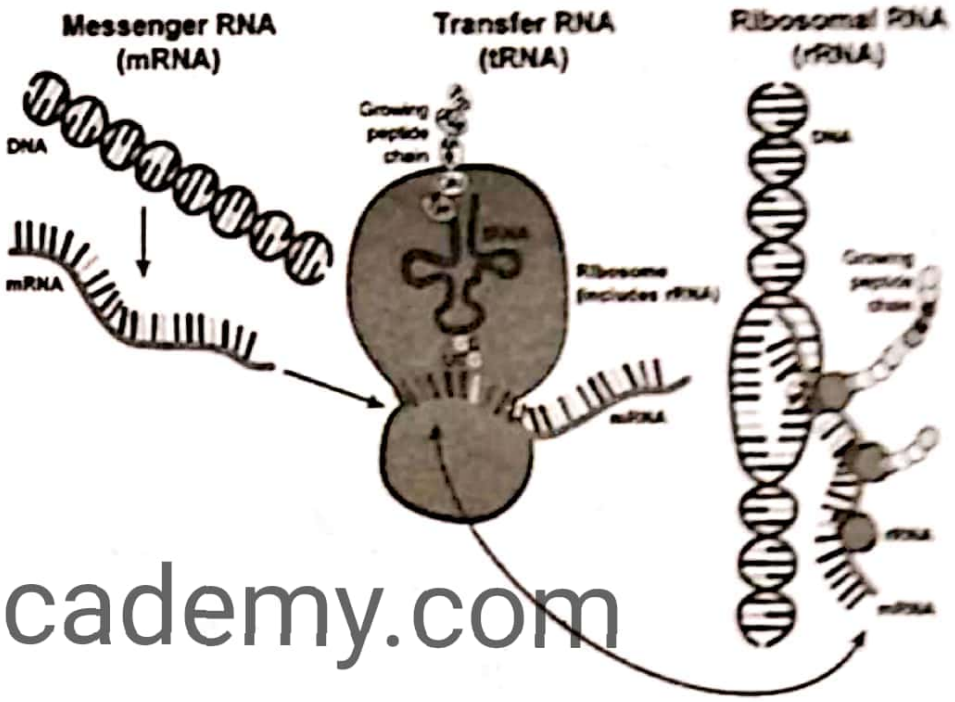
i. Messenger RNA (mRNA)
ii. Transfer RNA (tRNA)
iii. Ribosomal RNA (rRNA)

i. **Messenger RNA (mRNA):** It carries the genetic information's from DNA molecule to the site of protein synthesis i.e. ribosome.

ii. **Transfer RNA (tRNA):** It transfers the specific amino acid to the site of protein synthesis i.e. ribosome, according to the message brought by mRNA.

iii. **Ribosomal RNA (rRNA):** Ribosome (Protein synthesis factory is composed) of proteins and rRNA. Hence it has a role in protein synthesis.

Ribonucleic acid (RNA)



RNA as a carrier of Genetic information

RNA (mRNA, tRNA and rRNA) has a role in protein synthesis. It carries the genetic information's from DNA molecule to the site of protein synthesis i.e. Ribosome.

Protein synthesis occur in two main steps

1. **Transcription:** The process of synthesis of mRNA from DNA molecule is known as transcription.

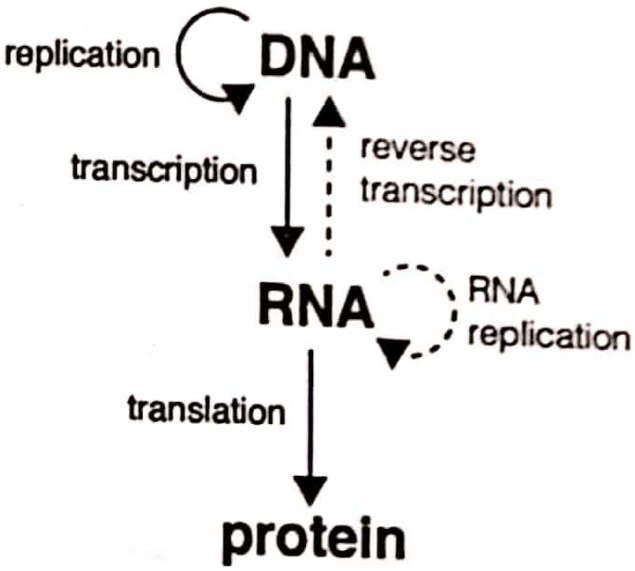
   OR

   The process of decoding of genetic information's from DNA molecule in the form of mRNA is known as transcription.

2. **Translation:** The process of synthesis of polypeptide chain i.e. protein according to the message (Genetic Code) brought by mRNA. It is known as translation.

Summary:

The genetic information brought by mRNA in the form of code (Genetic Code/Triplet Code) is translated into polypeptide chain (i.e. protein).



DNA makes RNA, RNA makes protein (protein synthesis).

Genetic Code

DNA is genetic material, it carries the genetic information from generation to generation. These genetic informations are existed in DNA molecule in the form of three nucleotide code known as genetic code or triplet code.

Genetic code for protein synthesis is contained in the base sequence of DNA. Genetic code is a code for amino acids .The genetic code is the relation between the base sequence of DNA and the amino acid sequence of the polypeptide chain (Protein).

In other words, the specific correspondence between a set of 3 bases and 1 of the 20 amino acids is called the genetic code.

The genetic code is the key that relates Nucleic acid language and the protein language.

TABLE OF GENETIC CODE

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC } Phe UUA, UUG } Leu	UCU, UCC, UCA, UCG } Ser	UAU, UAC } Tyr **UAA Stop** **UAG Stop**	UGU, UGC } Cys **UGA Stop** UGG Trp	U C A G
C	CUU, CUC, CUA, CUG } Leu	CCU, CCC, CCA, CCG } Pro	CAU, CAC } His CAA, CAG } Gln	CGU, CGC, CGA, CGG } Arg	U C A G
A	AUU, AUC, AUA } Ile **AUG Met**	ACU, ACC, ACA, ACG } Thr	AAU, AAC } Asn AAA, AAG } Lys	AGU, AGC } Ser AGA, AGG } Arg	U C A G
G	GUU, GUC, GUA, GUG } Val	GCU, GCC, GCA, GCG } Ala	GAU, GAC } Asp GAA, GAG } Glu	GGU, GGC, GGA, GGG } Gly	U C A G

DNA as Heredity material

Chromosome is composed of DNA and Proteins. DNA is the data bank of living organisms. For example, Human DNA contain all the data such as color of hairs, skin, eyes, height of body, size, appearance and morphology of nose, fingers, ears, eyes etc.

This data can be encoded in four different types of bases (i.e. adenine, Guanine, Cytosine and thymine). Biologists conducted experiments and proved that DNA is the genetic material and is responsible for the transfer of Genetic information from parents to offspring.

Transformation Experiment

In 1928, Griffith performed, experiments using pneumococcal bacteria that causing pneumonia in mice. He used two types of pnemococcus bacteria.

i. Pathogenic bacteria ii. Non Pathogenic bacterial

He observed that the non-pathogenic bacteria have absorbed genetic material (DNA) from the pathogenic bacteria. As a result non-Pathogenic bacteria have been transformed (changed) to pathogenic bacteria and caused pneumonia in mice.

Later on Avery, McLeod, and Mc Carty (1944) provided experimental evidence to prove that the virulence of pnemococcus bacteria is due to its outer surface. This character can be transmitted through DNA to non-pathogenic bacteria.

➢ Hershey and Chase Experiment

They studied the life history of bacteriophage (Bacterio-Bacterium, Phage - eating) for further conclusive evidence. Bacteriophage is the virus which attacks on Bacterium. Bacteriophage consist of DNA enclosed in protein coat. When bacteriophage injects its DNA in to Bacterial cell, leaving its protein coat outside.

The phage DNA gives instructions to Bacterial DNA, then it synthesizes phage DNA and Protein Coat. This is a proof that DNA is the genetic material or heredity material.

➢ Conjugated Molecules

When two macromolecules belonging to two different groups combine together, it forms conjugated molecules. For example:

1. **Glycoproteins:** It is formed by the combination of carbohydrates and proteins. Glycoprotein's is present in plasma membrane.
2. **Glycolipids:** It is also known as cerebrosides. It is formed by the combination of carbohydrates and lipids. It is present in brain and also in cell membranes.
3. **Lipoproteins:** It is formed by the combination of lipids and proteins.

   Lipoproteins form basic structural framework of plasma membrane and all other types of membranes in the cell.
4. **Nucleoproteins:** It is formed by the combination of nucleic acids and proteins. e.g. Chromosome = DNA + proteins

   Ribosome = RNA + proteins